



New records and confirmation of the presence of three species of primates (Mammalia, Primates) in southwestern Colombia

Héctor E. Ramírez-Chaves^{1,2}, Juan D. Carvajal-Agudelo², Manuel Hoyos R.³, Sebastián Bustamante-Manrique^{4,5,6}, Alejandra Castaño-Rivera⁶, Maria Alejandra Rivillas-Carmona⁶, Paula A. Ossa-López², Fredy A. Rivera-Páez²

1 Departamento de Ciencias Biológicas, Facultad de Ciencias Exactas y Naturales, Universidad de Caldas, and Centro de Museos, Museo de Historia Natural, Universidad de Caldas, Calle 65 N° 26-10, 170004, Manizales, Caldas, Colombia. **2** Grupo de Investigación en Genética, Biodiversidad y Manejo de Ecosistemas, Departamento de Ciencias Biológicas, Facultad de Ciencias Exactas y Naturales, Universidad de Caldas, Calle 65 N° 26-10, 170004, Manizales, Caldas, Colombia. **3** Grupo de Investigación en Evolución y Ecología de Mamíferos Neotropicales, Universidad Nacional de Colombia, Bogotá, Colombia. **4** Laboratório de Primatologia, Escola de Ciências da Saúde e da Vida, Pontifícia Universidade Católica do Rio Grande do Sul, Av. Ipiranga 6681, Prédio 12D, 90619–900, Porto Alegre, RS, Brasil. **5** Programa de Pós-graduação em Ecologia e Evolução da Biodiversidade, Escola de Ciências da Saúde e da Vida, Pontifícia Universidade Católica do Rio Grande do Sul, Av. Ipiranga 6681, 90619-900, Porto Alegre, RS, Brasil. **6** Semillero de Investigación en Primatología y Conservación de sus Ecosistemas, Departamento de Ciencias Biológicas, Facultad de Ciencias Exactas y Naturales, Universidad de Caldas, Calle 65 N° 26-10, 170004, Manizales, Caldas, Colombia.

Corresponding author: Héctor E. Ramírez-Chaves, hector.ramirez@ucaldas.edu.co

Abstract

Aotus lemurinus I. Geoffroy, 1843, *Cebus albifrons* (Humboldt, 1812), and *Sapajus apella* (Linnaeus, 1758) are widely distributed primates in Colombia. Despite this, there are gaps in the occurrence of these species in the southwestern part of the country. Through the collection of specimen remains, molecular analyses and review of museum specimens, we reported new records for these species in the Department of Nariño, Colombia, expanding their distribution range. Finally, we highlight some important notes for the conservation of these species.

Keywords

Aotus, *Cebus*, Colombian Night Monkey, Humboldt's White-fronted Capuchin, Large-headed Capuchin, *Sapajus*.

Academic editor: Thiago Borges Semedo Fernandes | Received 26 March 2020 | Accepted 24 June 2020 | Published 1 July 2020

Citation: Ramírez-Chaves HE, Carvajal-Agudelo JD, Hoyos MR, Bustamante-Manrique S, Castaño-Rivera A, Rivillas-Carmona MA, Ossa-López PA, Rivera-Páez FA (2020) New records and confirmation of the presence of three species of primates (Mammalia, Primates) in southwestern Colombia. Check List 16 (4): 831–839. <https://doi.org/10.15560/16.4.831>

Introduction

In Colombia, five species of capuchin monkeys of the genus *Cebus* Erxleben, 1777 and one species of the genus *Sapajus* Kerr, 1792 are currently recognized: *C. albifrons* (Humboldt, 1812), *C. capucinus* (Linnaeus, 1758), *C. leucocephalus* Gray, 1865, *C. versicolor* Pucheran, 1845, *C. malitiosus* Elliot, 1909, and *S. apella* (Linnaeus, 1758) (Cuervo Díaz et al. 1986; Alberico et al.

2000; Defler 2003; Boubli et al. 2012; Lynch Alfaro et al. 2012a). Of these species, *C. albifrons* and *S. apella* have a wide distribution in Colombia. *C. albifrons* is distributed from the Cordillera Oriental, east to the Amazonia and Orinoco (south of the Vichada River and west of the Orinoco River), in an elevational range from 0 to 2,000 m a.s.l., and *S. apella* is found in the Amazonia

and Eastern Llanos, with some populations on the flanks of the southern part of Cordillera Oriental of Colombia (Cuervo-Díaz et al. 1986; Alberico et al. 2000; Defler 2010; Ramírez-Chaves et al. 2010; Boubli et al. 2012; Lynch Alfaro et al. 2012b). It should be noted that the recognition of these two genera and the taxonomy of *C. albifrons* have been widely debated, presenting multiple changes in their systematics (Silva 2001; Grooves 2001, 2005; Boubli et al. 2012; Lynch-Alfaro et al. 2012a, 2012b; Ruiz-Garcia et al. 2012; Garbino 2015; Lima et al. 2017; Martins-Junior et al. 2018; Ruiz-Garcia et al. 2018). In addition, *S. macrocephalus* (Spix, 1823) has been listed as the only species of *Sapajus* distributed in Colombia (de la Torre et al. 2018), although the taxonomy of the genus in Colombia has not been reviewed.

For the Department of Nariño, in southwestern Colombia, the presence of *C. albifrons*, *C. capucinus*, and *S. apella* (as *Cebus/Sapajus apella*), has been mentioned in the literature (Cadena et al. 1998; Alberico et al. 2000; Ramírez-Chaves and Noguera-Urbano 2010). Defler (2003) suggested that *C. albifrons* and *S. apella* could occur in the Amazonian plain of the department, but there are no voucher specimens to corroborate this assumption. Furthermore, despite the wide distribution of *C. albifrons* and *S. apella* in Colombia, there are still many poorly known areas where their presence is probable but has not been confirmed (Hernández-Camacho and Cooper 1976).

For the night monkey genus *Aotus* Illiger, 1811, eight species have been recognized in the national territory (Defler 2003; Defler and Bueno 2007; Maldonado and Peck 2014): *A. brumbacki* Hershkovitz, 1983, *A. griseimembra* Elliot, 1912, *A. lemurinus* I. Geoffroy, 1843, *A. jorgehernandezi* Defler & Bueno, 2007, *A. trivirgatus* (Humboldt, 1811), *A. vociferans* (Spix, 1823), *A. zonalis* Goldman, 1914, and *A. nancymae* Hershkovitz, 1983. The genus is known throughout Colombia, except in the north-eastern La Guajira desert, in areas above 3,200 m a.s.l., in Vichada north of the Tomo River, in eastern Casanare and Arauca, and in some mountainous and shrubby areas of Guainía, Vaupés and Guaviare departments (Hernández-Camacho and Cooper 1976; Defler 2003). Currently, there are no vouchered records for the Department of Nariño either (Defler 2003).

Given the circumstances mentioned above, this paper aims to corroborate the presence of *A. lemurinus*, *C. albifrons* and *S. apella* in the Eastern Andes of Department of Nariño, an area poorly studied in terms of biodiversity and under increasing pressure due to the agricultural frontier expansion. We also provide information on the presence of other primates in this department.

Methods

The records come from the village of Monopamba, municipality of Puerres, Department of Nariño, southwestern Colombia (Fig. 1). The municipality of Puerres is located in the eastern mountain range (Cordillera

Oriental) of Nariño. Most of the territory in the area is mountainous, however there are flat areas located in the Sucio River and Alisales valleys. The most important economic activities are agriculture, livestock and trade. The average annual temperature is 13 °C and the average annual rainfall is 1,060 mm. The municipal area is 359 km² and borders Funes to the north, Funes and the Department of Putumayo to the east, the municipalities of Córdoba to the south, and Córdoba and Contadero to the west. The municipality includes the town of San Mateo and the police stations of El Páramo, Muicira and Monopamba (IGAC 1996).

In Monopamba, three locations were visited: the town of Monopamba (1,721 m a.s.l.), the village of El Verde, near Alisales River (1,873–1,931 m a.s.l.), and the village of El Verde, Playas (2,117 m a.s.l.). Monopamba is a compound word from Spanish and Quichua that means “plain of the monkeys” (pamba is a word that comes from Pampa = plain) (Albor 1972), a fact that led us to investigate the current or historical presence of these organisms in the locality in question and surrounding sectors.

The information comes from a rapid field assessment conducted in April 2009 in three locations in the municipality of Puerres (Monopamba, El Verde, and Playas), Department of Nariño. There, we conducted informal interviews with local inhabitants, including hunters, using illustrations of Neotropical mammals (Eisenberg 1989; Emmons and Feer 1999) likely to be present in the area. In addition, we searched for traces and indirect evidence of the presence of these organisms (i.e., skins and skeletal remains), in order to verify the identity of the records.

The skulls and other samples are deposited in the mammal collection of the Universidad Distrital Francisco José de Caldas Museum (MUD), Bogotá. The identification was confirmed after comparison with reference specimens deposited in the collection of the Natural History Museum of the Universidad del Cauca (MHNUC), Popayán, and the Natural History Museum of the Universidad de Caldas (MHN-UCa). We also reviewed specimens of the genus *Aotus* from Ecuador deposited in the collections of the Museo Escuela Politécnica Nacional (MEPN) and the Pontificia Universidad Católica de Ecuador (QCAZ).

Molecular analysis was carried out with tissue samples of a specimen of *Aotus* from the Department of Nariño and two specimens of *A. lemurinus* from the Department of Caldas, deposited in the MHN-UCa (MHN-UCa 1503–1504). DNA extraction was performed using the DNeasy Blood and Tissue kit (Qiagen), following the manufacturer’s protocol. Confirmation of identity and phylogenetic analysis of the *Aotus* specimen was examined through the amplification of the mitochondrial cytochrome *b* (cyt *b*) gene using the primers Prim_ND6L1 (5'-CAACCCACAGCACCCTA-3') and Prim_ProH1 (5'-TAGAATTTTCAGCTTGGGTT-3') primers (Hoyos et al. 2016). Following the conditions; initial denaturation step of 2 min at 94 °C, 34 cycles of 30 s at 94 °C, 30 s at 50 °C, and 2 min at 72 °C followed

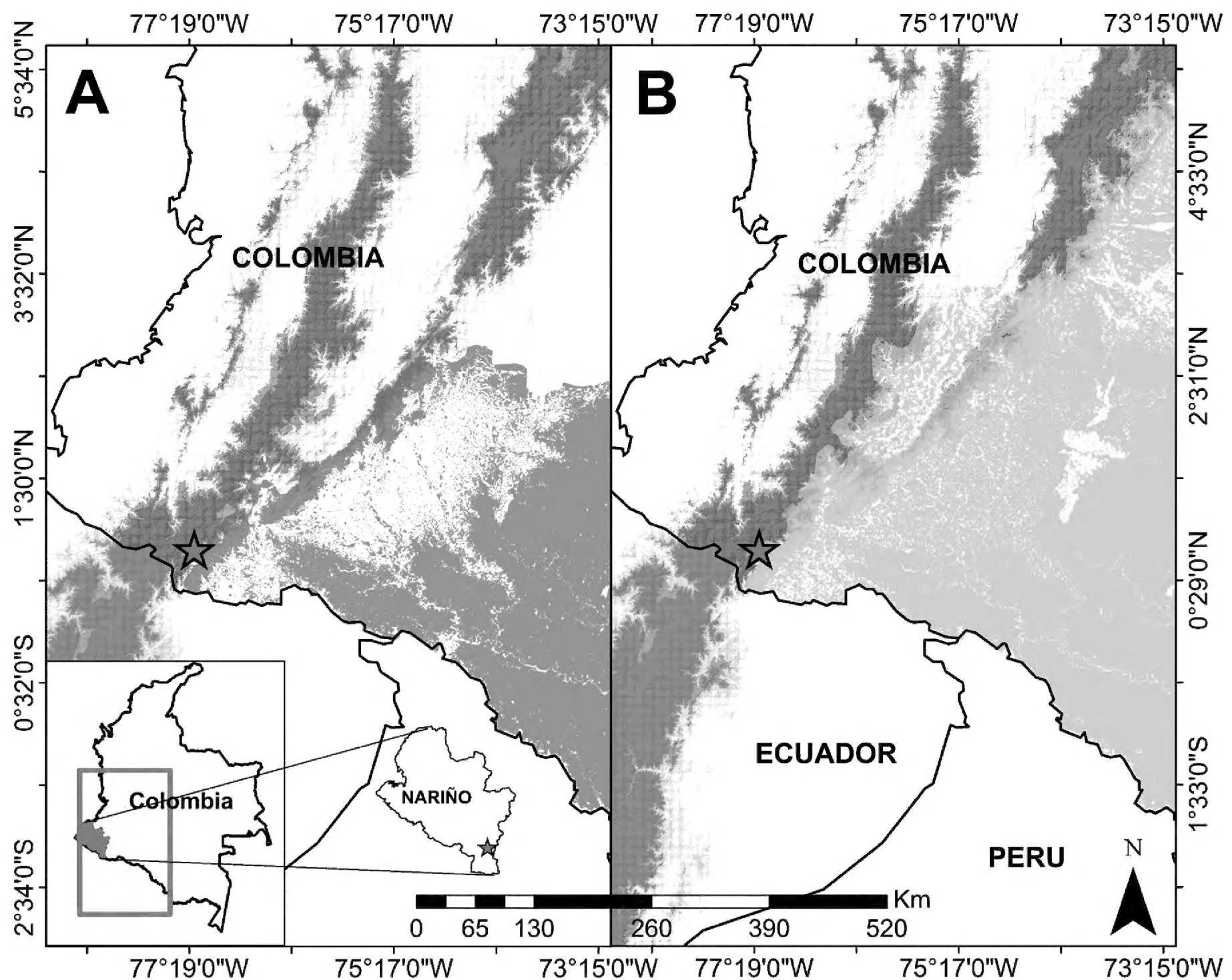


Figure 1. The distribution area of **A.** *Cebus albifrons* and **B.** *Sapajus apella* in Colombia. The red star shows the new locality for both species in Department of Nariño, village of Monopamba. Shapes are based on Link (2018) and Carretero-Pinzón and Stevenson (2018), respectively.

by a final extension at 72 °C for 10 min. The PCR products were purified with the QIAquick PCR purification kit (Qiagen) and sent to Macrogen Inc (South Korea) for DNA sequencing. The sequences were analyzed using Basic Local Alignment Search Tool (BLAST; Madden 2013) to determine the closest similarities with other *Aotus* species. Sequences were aligned using the algorithms present in CLUSTALW (Thompson et al. 1994). Phylogenetic analyses were carried out using maximum likelihood (ML) and Neighbor-Joining (NJ) algorithms and bootstrap support was estimated using 1000 pseudo-replications. Both alignment and phylogenetic analyses were carried out in Mega X (Kumar et al. 2018). The following sequences of *Aotus* available from GenBank were included: FJ785421, DQ098869, HQ005508, HQ005507, DQ098873, DQ098874, DQ098863, DQ098864, HQ005495, HQ005496, HQ644333 (see Table 1).

Results

Cebus albifrons (Humboldt, 1812)

Figures 1A, 2A

New record. COLOMBIA • 1 skull; Department of Nariño, Municipality of Puerres, El Verde village; 00° 46'N,

077°17'W; 1,931 m a.s.l.; Apr. 2009; H. E. Ramírez-Chaves leg; donated by local hunters; MUD 763.

Identification. The measurements obtained from the skull (Fig. 2A) are: greatest length of the skull: 98.27 mm; height of the skull (from the basisphenoids to the top of the skull): 48.01 mm; width of the skull: 54.75 mm; greatest distance across the upper molars: 31.62 mm; length of the upper dental series (from canine to third molar): 28.5 mm estimated using the alveoli of the last molar, which had fallen; length of the lower dental series: 33.61 mm; length of the mandible: 69.95 mm; a zygomatic arch was broken, the back of the skull is broken; the sagittal crest is not very developed. The skull (MUD 763) was identified following the cranial descriptions posed for the species by Hershkovitz (1949). It has a poorly developed sagittal crest and smaller cranial measurements than in *S. apella*.

Sapajus apella (Linnaeus, 1758)

Figures 1B, 2B

New record. COLOMBIA • 1 skull; Department of Nariño, Municipality of Puerres, El Verde village; 00° 46'N, 077°17'W; 1,931 m a.s.l.; Apr. 2009; H. E. Ramírez-Chaves leg; donated by local hunters; MUD 762.

Table 1. List of sequenced specimens of *Aotus* included in our cytochrome *b* analyses.

Taxon	Genbank Accesion	Locality	Source
<i>Aotus cf. lemurinus</i>	MT253565	Colombia: Nariño, Puerres	This study; MUD 764
<i>Aotus lemurinus</i>	MT232916	Colombia: Caldas, Manizales	This study; MHN-UCa 1503
<i>Aotus lemurinus</i>	MT232915	Colombia: Caldas, Manizales	This study; MHN-UCa 1504
<i>Aotus lemurinus</i>	FJ785421	No locality provided	Hodgson et al. 2009
<i>Aotus lemurinus/griseimembra</i>	DQ098869	Colombia: Sucre, San Marcos	Ribeiro et al. 2005
<i>Aotus nancymae</i>	HQ005507	Colombia: Amazonas, Leticia	Menezes et al. 2010
<i>Aotus nancymae</i>	HQ005508	Colombia: Amazonas, Leticia	Menezes et al. 2010
<i>Aotus infulatus</i>	HQ005496	Brazil: Pará, Ilha do Marajó	Menezes et al. 2010
<i>Aotus infulatus</i>	HQ005495	Brazil: Maranhão, São Miguel	Menezes et al. 2010
<i>Aotus azarae</i>	DQ098864	Brazil: Rondônia, Samuel Dam reservoir	Ribeiro et al. 2005
<i>Aotus azarae</i>	DQ098863	Brazil: Rondônia, Samuel Dam reservoir	Ribeiro et al. 2005
<i>Aotus nigriceps</i>	HQ005498	Brazil: São Paulo, São Paulo Zoo	Menezes et al. 2010
<i>Aotus trivirgatus</i>	DQ098874	Brazil: Amazonas, North of the Rio Negro	Ribeiro et al. 2005
<i>Aotus trivirgatus</i>	DQ098873	Brazil: Amazonas, North of the Rio Negro	Ribeiro et al. 2005
<i>Alouatta seniculus</i>	HQ644333	Ecuador: Orellana, Yasuní Biosphere Reserve	Di Fiore et al. 2015

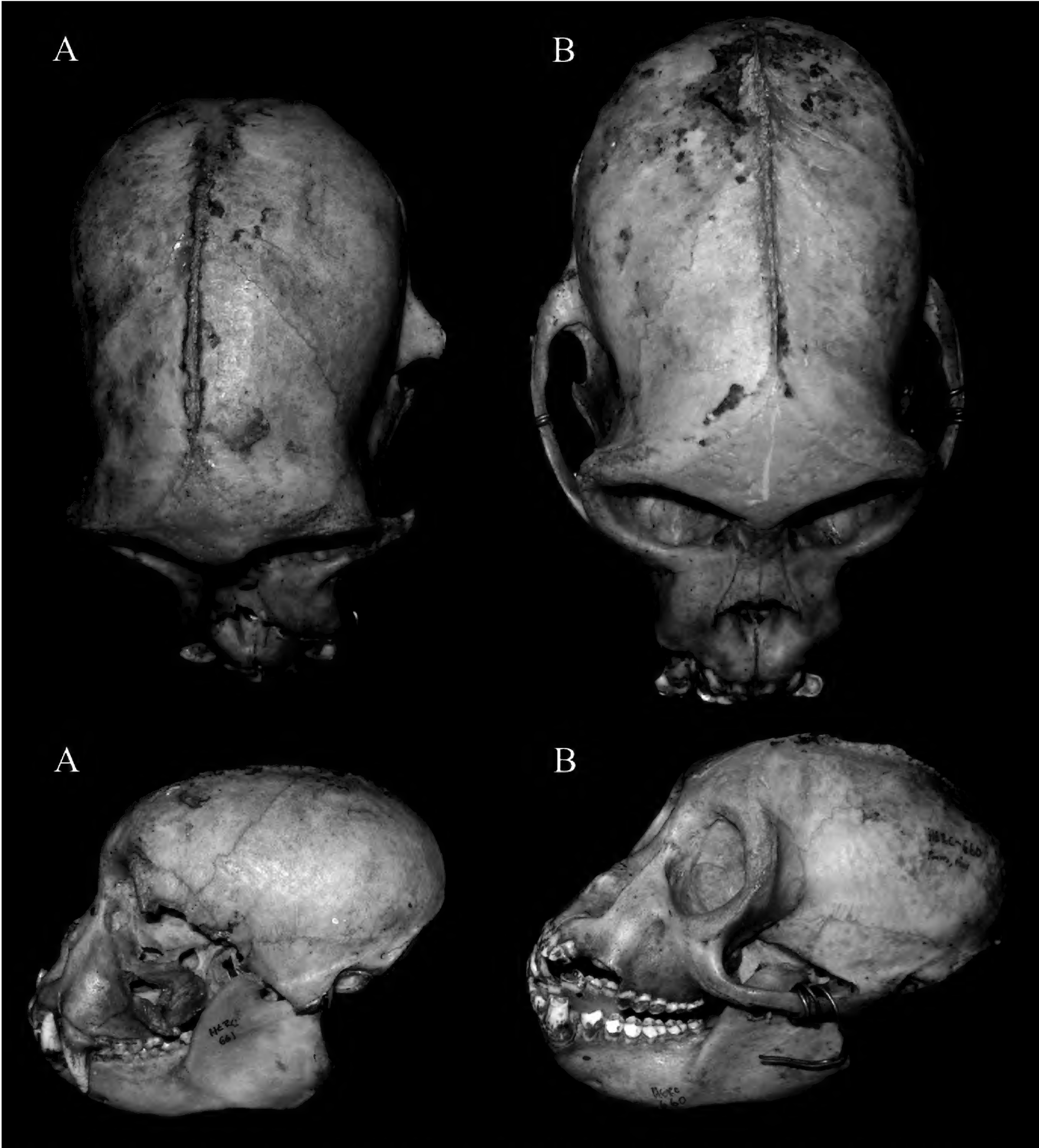


Figure 2. Dorsal and lateral views of the skulls of **A.** *Cebus albifrons* (MUD 763; greatest length of the skull: 98.27 mm), and **B.** *Sapajus apella* (MUD 762; greatest length of the skull: 108.11 mm).

Identification. The cranial measurements obtained were: greatest length of the skull: 108.11 mm; height of the skull: 50.45 mm; width of the skull: 55.58 mm; zygomatic width: 71.12 mm; width across the orbits: 55.15 mm; distance across the upper molars: 32.1 mm; length of the lower dental series: 39.57 mm; length of the jaw: 74.05 mm. The skull (MUD 762; Fig. 2B) was identified based on its cranial measurements, which are shared with those described for *S. apella* by Hershkovitz (1949) and Lynch-Alfaro et al. (2012a). The skull had a marked sagittal crest, and was larger, more robust, than those of *C. albifrons*.

Aotus lemurinus I. Geoffroy, 1843

Figures 3, 4

New record. COLOMBIA • 1 juvenile ♀; Department of Nariño, Municipality of Puerres, El Verde village; 00°46'N, 077°17'W; 1,931 m a.s.l.; Apr. 2009; H. E. Ramírez-Chaves leg.; found dead and preserved as skin, skull and skeleton; GenBank: MT253565; voucher: MUD 764.

Identification. The specimen has the following

characteristics: long dorsal coat (individual hairs approximately 38 mm long); temporal and frontal stripes visible and conspicuous, black. Malar stripe not apparent. Chest and abdomen yellow orange, back with a wider, opaquer middorsal band extending from the mantle to the tail, with reddish or yellowish marbling; hind legs yellowish grey, even with the sides. Distal part of tail black reaching almost 60% of tail length. Through interviews with the local inhabitants, we obtained information about the presence of a small, large-eyed monkey that lived in the forest areas of the region in small groups and was occasionally captured; this description matched with monkeys of the genus *Aotus*. The search for traces and information about the mentioned animal led us to locate a dead specimen that was kept as a pet and that had been captured only a week before in a forest near Afiladores Stream in the village of El Verde. The specimen had been recently buried, so we were able to recover the body (including the skin) and to collect tissue samples.

The coloration of this specimen coincides with the observed in other representatives of *A. lemurinus* from

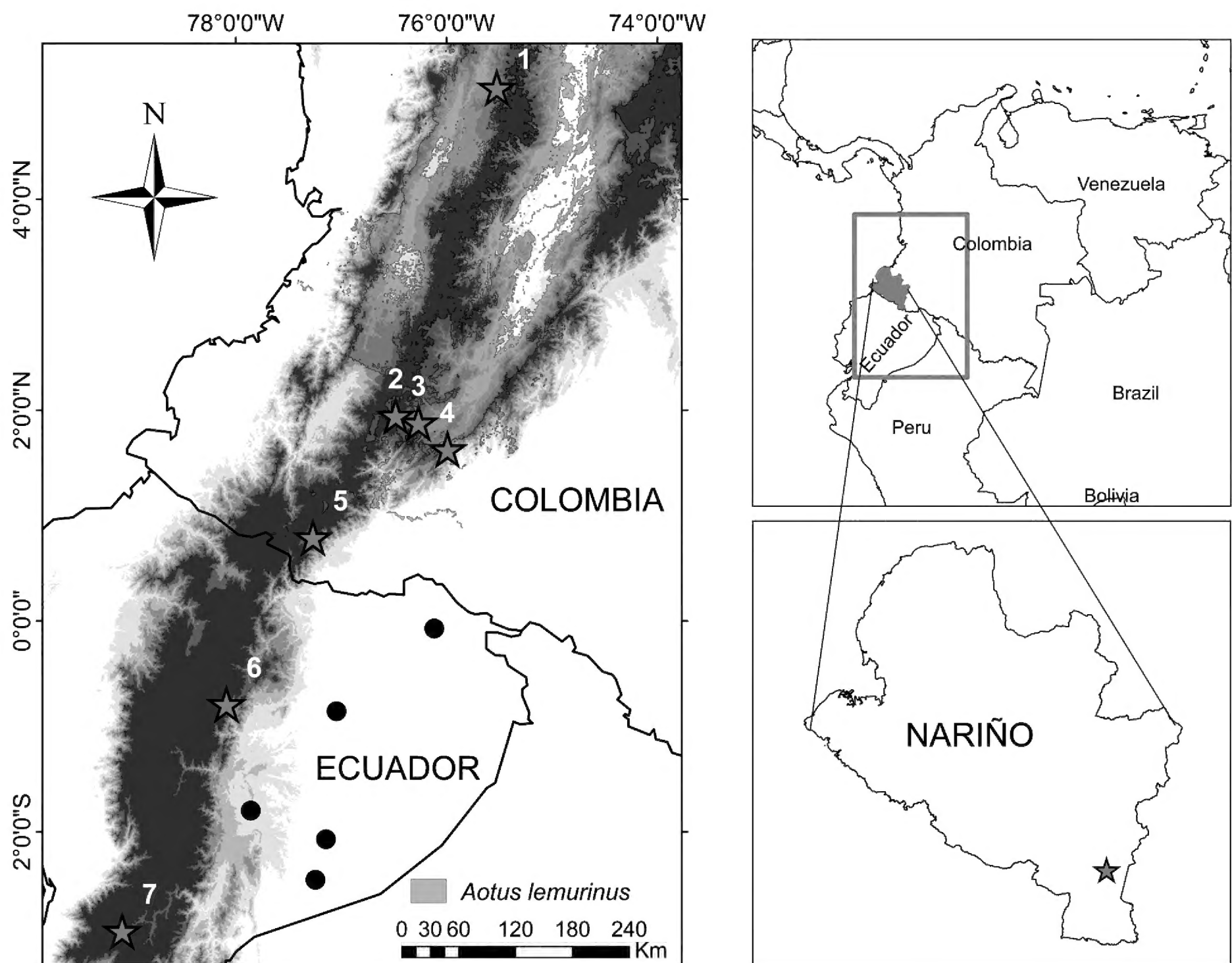


Figure 3. Reviewed records of *Aotus lemurinus* (yellow stars) from Colombia and Ecuador. Records from Colombia includes: (1) Department of Caldas, Manizales (MHN-UCa 1503, 1504); (2) Department of Cauca, Puracé, Moscopán (MHNUC 073); (3) Department of Huila, San Agustín (Field Museum of Natural History, FMNH 70680); (4) Department of Huila, municipality of Acevedo, Aguas Claras River (FMNH 70676); (5) First record from Department of Nariño, village of Monopamba (red star, MUD 764). Records from Ecuador include: (6) Province of Napo, Cosanga, San Isidro (QCAZ 8984), and (7) Province of Azuay, Urco (MEPN 7918). Black circles show the records of *Aotus vociferans* from Ecuador housed at MEPN and QCAZ.

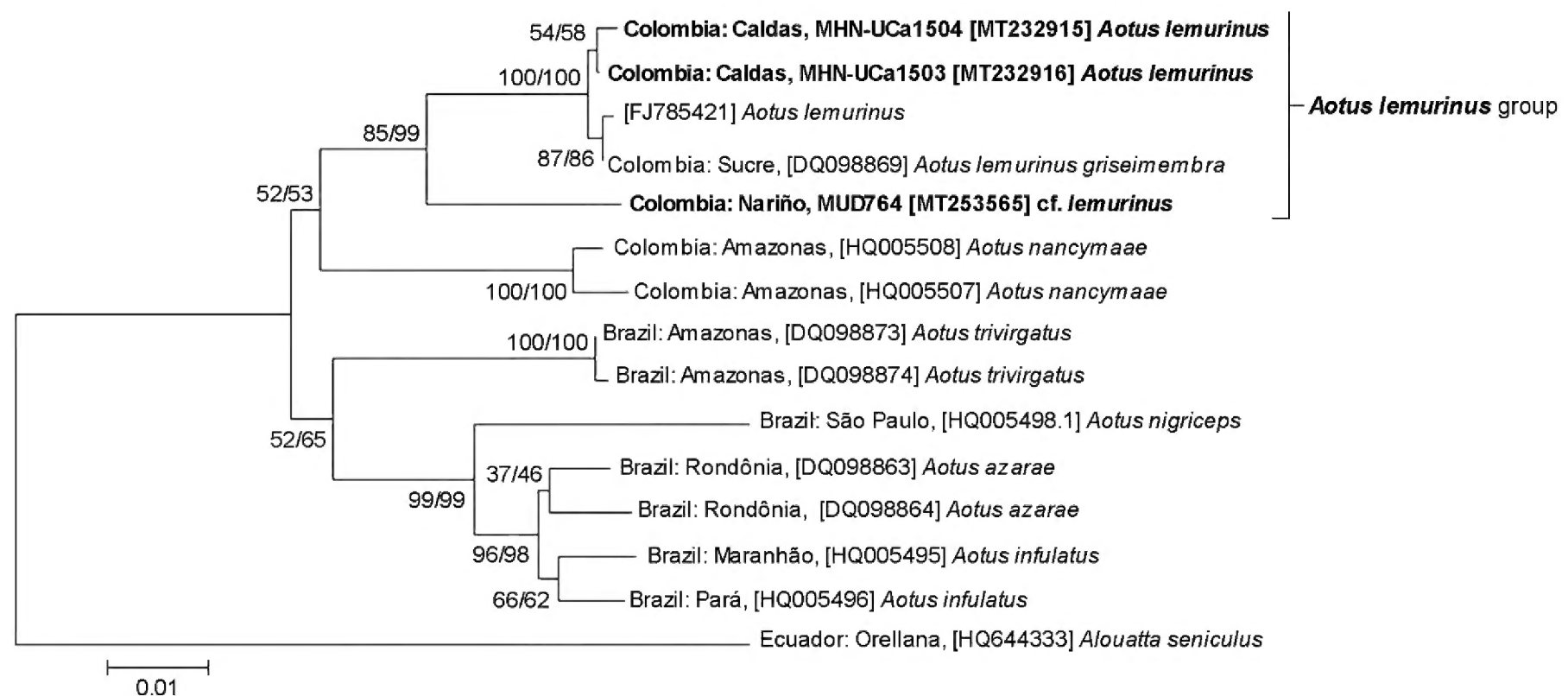


Figure 4. Cytochrome *b* gene tree inferred using maximum likelihood (ML) and Neighbor-Joining (NJ) algorithms based on partial sequences using the Mega X software. The specimens sequenced in this study are in bold. GenBank-retrieved sequences are in square brackets [access numbers]. *Alouatta seniculus* was added as an outgroup. ML bootstrap/ NJ bootstrap values are indicated in front of each clade, respectively.

Moscopán (02°14'N, 076°10'W; 2,400 m a.s.l.), municipality of Puracé, Cauca (MHNUC 073 ♂), and from Salento (04°38'N, 075°34'W), Department of Quindío (MHNUC 072 ♂). On the other hand, phylogenetic analysis of the *cyt b* gene recovered the specimen from Monopamba, Nariño (Fig. 4; MUD 764) as sister to the clade containing the *A. lemurinus* specimens obtained from GenBank and the sequences from the Department of Caldas (MHN-UCa 1503, 1504) (Fig. 4). This group is highly supported by ML / NJ bootstrap values (85/99, respectively). In addition, the *cyt b* sequence of the specimen in question was highly similar (96.53 %) to available sequences corresponding to *A. lemurinus* (GenBank: FJ785421) and *A. trivirgatus* (GenBank: AY250707). However, the latter is only found in the lowlands of the Orinoco and Amazon regions of Venezuela and Brazil, with no confirmed records from Colombia (Urbani et al., 2018).

GenBank nucleotide sequence accession numbers for the partial sequences generated for specimens from the Department of Caldas are MT232916 for voucher specimen MHN-UCa 1503, and MT232915 for specimen MHN-UCa 1504.

Other records and additional information. The other species recorded only through interviews are the choro monkey (*Lagothrix* sp.) from which we could not obtain tangible evidence to corroborate its presence, although it seems to be well known locally. Among the three species reported here, the inhabitants of Monopamba claim that they are commonly observed in the sector and are generally (except for *A. lemurinus* which is usually captured for pets) consumed by humans.

Discussion

We provide novel information on the distribution of three species of primates in southwestern Colombia we also suggest future research in the area. The record of *Cebus albifrons* represents a distribution extension in the department. The presence of this species was suggested for south of the Guamuez River, near the Department of Putumayo (Defler 2003; de la Torre et al. 2015), corresponding to the Amazon plain of the department. However, the record presented here comes from the Andean region (1,800–1,900 m a.s.l.), south of the upper basin of the Guamuez River, on the eastern flank of the Eastern Cordillera. The cranial measurements of the collected specimen of *C. albifrons* are congruent with those proposed by Hershkovitz (1949) for *C. a. cuscinus* Thomas, 1901 and *C. a. yuracus* (Humboldt, 1812) although apparently there are no reasons for the recognition of these subspecies (Ruiz-García et al. 2010). The only previous record of *C. albifrons* from Nariño at the Rumiayaco–Ranchería River Basin (00°26'N, 077°16'W, 755 m a.s.l.), bordering the departments of Nariño and Putumayo, is a skull obtained in September 1998, that is deposited in the mammal collection of the Alexander von Humboldt Institute - IAvH, Villa de Leyva (IAvH 6070).

The record of *Sapajus apella* also corroborates the presence of this species in the Eastern Andes of the Department of Nariño. The distribution of *S. apella* had been suggested as probable for the Nariño Amazon plain (Defler 2003), but de la Torre et al. (2018), naming the taxon as *S. macrocephalus*, did not include Nariño within the species' range. The measures of the *S. apella* specimen are concordant with those present in Hershkovitz (1949) and every cranial dimension is superior to those of *C. albifrons*. When comparing the skulls of *S. apella* and *C. albifrons*, the former has a more conspicuous development of the sagittal crest (Fig. 2).

For *Aotus lemurinus*, our record (MUD 764) represents the first confirmed record of the genus for the Department of Nariño and the locality of origin is approximately 50 km north from the border with Ecuador (Fig. 3). Defler (2003) mentioned that there are gaps in the geographical distribution of *Aotus* in this department, which require further ecological and geographical research to understand this type of ecological limitation. Nevertheless, the presence of *A. lemurinus* in the region was expected due to the environmental conditions in the department and because the species has been recorded for the eastern foothills of the Eastern Cordillera of Ecuador, between 900 and 1,800 m a.s.l. (Morales-Jiménez and de la Torre 2008). Although the presence of *A. lemurinus* in Ecuador is debated because the few known records are based only on field observations and the scarce existing museum material has not been properly analyzed (Tirira 2007), we were able to confirm that two specimens from Ecuador have the external diagnostic characteristics of *A. lemurinus*: MEPN 7918 from Ramos Stream, Urco, Azuay, Ecuador (02°53'S, 058°79'W; Fig. 3), has the reddish coloring observed in *A. lemurinus*, long coat: 36.7 mm in the interscapular region; very long feet hairs (12 mm) that reach and surpass the nails approximately 7.5 mm (this is the most evident difference when compared with the other *Aotus* of Ecuador deposited in MEPN). The second specimen (QCAZ 8924) from Cosanga, San Isidro, Ecuador (00°34'S, 077°52'W), has hair on its forefeet protruding beyond the nails, long and woolly fur and facial stripes as those of *A. lemurinus*, but it is a young specimen. Twelve additional specimens (Appendix) from different Ecuadorian localities of the genus *Aotus* deposited in MEPN and QCAZ have the diagnostic characters of *A. vociferans*.

The genus *Aotus* taxonomy is complex (Defler 2003) due to the lack of karyological and morphological information necessary to clearly understand the relationships between populations (Hershkovitz 1983). According to Defler et al. (2003), new studies are required to understand the geographical distribution of Colombian *Aotus* species. In Ecuador it is considered a priority to carry out an intense search for this species with the collection of specimens, taking of photographs and tissue samples, so that its identification can be reliably determined (Tirira 2007). To help to clarify these taxonomic issues, the *cyt b* gene that has been widely used for the identification of specimens of other taxonomically complex Neotropical primates (e.g., Hoyos et al. 2016; Martins-Junior et al. 2018). Our results using *cyt b* sequences suggest that the specimen from the Department of Nariño is the sister-group of a clade formed by *A. lemurinus* from Colombia. This is consistent with the presence of the species according to its range (Defler et al. 2001; Ramírez-Chaves and Noguera-Urbano 2010). However, according to the limited amount of characters used to identify this specimen, the existence of undetected cryptic diversity in *A. lemurinus* species cannot be ruled out. Accordingly, we strongly recommend a further taxonomic assessment of

this *Aotus* population, including more specimens from Colombia and Ecuador, and additional molecular loci.

Conservation. Of the three registered primate species, *Aotus lemurinus* has been catalogued as Vulnerable due to their restricted distribution, hunting and habitat loss (Defler and Rodríguez-Mahecha 2006). The main threats to its small populations are human actions, as large part of its distribution is interspersed with heavily impacted areas (Defler and Rodríguez-Mahecha 2006; Morales-Jiménez and de la Torre 2008). According to the inhabitants of the areas visited, the populations of these three primate species are large, but additional studies are needed to support this claim. It is also necessary to develop research on the population densities of these species to establish the degree of threat they may present locally and other sources of pressure. In the past, hunting activities were carried out using dogs and rifles in the study area, but the inhabitants of the towns visited claim that since the arrival of the guerrillas in the area, they have not carried out constant hunting activities (for approximately more than ten years). Locals stated that large and medium-sized mammal species are found relatively easily and in sectors like El Verde, and are commonly hunted for food due to the lack of domestic animals, generated by the difficult access to this area. The conservation efforts should be concentrated at the local level, that is, in the regions where the populations of the threatened species are found (Defler 2003; Defler et al. 2003; Defler and Rodríguez-Mahecha 2006). *Cebus albifrons* and *Sapajus apella* are not in any national threat category, but in the studied area they are usually hunted because they impact the corn crops. The primate species registered here occur in the protected area Orito Ingi-Ande Flora Sanctuary (00°42'N, 076°54'W approximately), which is located between the municipalities of Funes, Department of Nariño, and Orito municipality in the Department of Putumayo.

Acknowledgements

We thank the mammal curators at the following collection: MHNUC (Pilar Rivas), MUD (Abelardo Rodríguez), QCAZ (Santiago Burneo and Alejandra Camacho), MEPN (Jhanira Regalado and Luis Albuja), and the Centro de Museos, Universidad de Caldas. Thanks to Vicerrectoría de Investigaciones, Universidad de Caldas (project 0743919) for support. HERC thanks Rufford Small Grants (Grants 23710-1 and 29491-2). We thank Guilherme Garbino and Thiago Semedo for providing useful comments that improved the manuscript.

Authors' Contributions

HERC collected data in Colombia and Ecuador and wrote the manuscript. MH, JDC, ACR, SBM, MARC, PAOL, FARP examined specimens at the Universidad de Caldas collections, obtained and analyzed the *cyt b* sequences, and wrote the paper.

References

- Alberico M, Cadena A, Hernández-Camacho J, Muñoz-Saba Y (2000) Mamíferos (Synapsida: Theria) de Colombia. *Biota Colombiana* 1: 43–75.
- Albor HR (1972) Apuntes lexicográficos del español hablado en Nariño – Quechuismos. *BICC, Boletín del Instituto Caro y Cuervo* 27: 333–345.
- Boubli JP, Rylands AB, Farias IP, Alfaro ME, Lynch Alfaro JW (2012) *Cebus* phylogenetic relationships: a preliminary reassessment of the diversity of the untufted capuchin monkeys. *American Journal of Primatology* 74 (4): 381–393. <https://doi.org/10.1002/ajp.21998>
- Cadena A, Anderson RP, Rivas-Pava MP (1998) Colombian mammals from the Chocoan Slopes of Nariño. *Occasional Papers, Museum of Texas Tech University* 180: 1–15.
- Carretero-Pinzón X, Stevenson P (2018) Modelo de distribución de *Sapajus apella* ID PRI-729. Laboratorio de Biogeografía Aplicada. Instituto Alexander von Humboldt, Colombia. http://biomodelos.humboldt.org.co/species/visor?species_id=932. Accessed on: 2020-6-24.
- Cuervo-Díaz A, Hernández-Camacho J, Cadena A (1986) Lista actualizada de los mamíferos de Colombia, anotaciones sobre su distribución. *Caldasia* 15: 471–502.
- de la Torre S, Morales AL, Link A, Cornejo F (2015) *Cebus albifrons* (errata version published in 2017). The IUCN Red List of Threatened Species 2015: e.T39951A115173470. <https://doi.org/10.2305/iucn.uk.2015.rlts.t39951a81236767.en>. Accessed on: 2020-4-30.
- de la Torre S, Boubli J, Calouro AM, Heymann EW, Lynch Alfaro J, Martins AB, Mollinedo J, Moscoso P, Ravetta A, Shane S, Urbani B (2018) *Sapajus macrocephalus*. The IUCN Red List of Threatened Species 2018: e.T42696A70613972. <https://doi.org/10.2305/iucn.uk.2018-2.rlts.t42696a70613972.en>. Accessed on: 2020-4-30.
- Defler TR (2003) *Primates de Colombia*. Conservación Internacional Colombia, Bogotá, 543 pp.
- Defler TR (2010) *Historia Natural de los Primates Colombianos*. Universidad Nacional de Colombia, Sede Bogotá, Facultad de Ciencias, Departamento de Biología, Bogotá, 543 pp.
- Defler TR, Bueno ML (2007) *Aotus* diversity and the species problem. *Primate Conservation* 22 (1): 55–70. <https://doi.org/10.1896/052.022.0104>
- Defler TR, Rodríguez-Mahecha JV (2006) Mico de noche andino complejo *Aotus lemurinus*. In: Rodríguez-Mahecha J, Alberico M, Trujillo F, Jorgenson J (Eds) *Libro rojo de los mamíferos de Colombia, Serie Libros Rojos de Especies Amenazadas de Colombia*. Conservación Internacional Colombia, Bogotá, 210–214.
- Defler TR, Bueno ML, Hernández-Camacho J (2001) Taxonomic status of *Aotus hershkovitzi*: its relationship to *Aotus lemurinus*. *Neotropical Primates* 9 (2): 37–62.
- Defler TR, Rodríguez-Mahecha JV, Hernández-Camacho J (2003) Conservation priorities for Colombian primates. *Primate Conservation* 19: 10–18.
- Di Fiore A, Chaves PB, Cornejo FM, Schmitt CA, Shane S, Cortés-Ortiz L, Fagundes V, Roos C, Pacheco V (2015) The rise and fall of a genus: Complete mtDNA genomes shed light on the phylogenetic position of yellow-tailed woolly monkeys, *Lagothrix flavicauda*, and on the evolutionary history of the family Atelidae (Primates: Platyrrhini). *Molecular Phylogenetics and Evolution* 82: 495–510. <https://doi.org/10.1016/j.ympev.2014.03.028>
- Eisenberg JF (1989) *Mammals of the Neotropics: the northern Neotropics*. Volume 1. Panama, Colombia, Venezuela, Guyana, Suriname, French Guiana. The University of Chicago Press, Chicago, 449 pp.
- Emmons LH, Feer F (1999) *Mamíferos de los bosques húmedos de América tropical, Una guía de campo*. Fundación Amigos de la Naturaleza, Santa Cruz de la Sierra, 298 pp.
- Garbino GST (2015) Defining genera of New World monkeys: the need for a critical view in a necessarily arbitrary task. *International Journal of Primatology* 36 (6): 1049–1064. <https://doi.org/10.1007/s10764-015-9882-9>
- Groves CP (2001) *Primate taxonomy*. Smithsonian Institution Press, Washington, 350 pp.
- Groves CP (2005) Order Primates. In: Wilson DE, Reeder DM (Eds) *Mammal species of the world: a taxonomic and geographic reference*, Johns Hopkins University Press, Baltimore, 111–184.
- Hernández-Camacho J, Cooper RW (1976) The nonhuman primates of Colombia. In: Thorington Jr RW (Eds) *Neotropical primates: field studies and conservation*, National Academy of Sciences, Washington, 35–69.
- Hershkovitz P (1949) *Mammals of northern Colombia*. Preliminary report no. 4: monkeys (Primates), with taxonomic revisions of some forms. *Proceedings of the United States National Museum* 98: 323–427.
- Hershkovitz P (1983) Two new species of night monkeys, genus *Aotus* (Cebidae, Platyrrhini): a preliminary report on *Aotus* taxonomy. *American Journal of Primatology* 4 (3): 209–243. <https://doi.org/10.1002/ajp.1350040302>
- Hodgson JA, Sterner KN, Matthews LJ, Burrell AS, Jani RA, Raam RL, Stewart C-B, Disotell TR (2009) Successive radiations, not stasis, in the South American primate fauna. *Proceedings of the National Academy of Sciences* 106 (14): 5534–5539. <https://doi.org/10.1073/pnas.0810346106>
- Hoyos M, Bloor P, Defler T, Vermeer J, Röhe F, Farias I (2016) Phylogenetic relationships within the *Callicebus cupreus* species group (Pitheciidae: Primates): biogeographic and taxonomic implications. *Molecular Phylogenetics and Evolution* 102: 208–219. <https://doi.org/10.1016/j.ympev.2016.05.031>
- Instituto Geográfico Agustín Codazzi (1996) *Diccionario geográfico de Colombia*. Instituto Geográfico Agustín Codazzi, Bogotá, 620 pp.
- Kumar S, Stecher G, Li M, Knyaz C, Tamura K (2018) MEGA X: Molecular Evolutionary Genetics Analysis across computing platforms. *Molecular Biology and Evolution* 35 (6): 1547–1549. <https://doi.org/10.1093/molbev/msy096>
- Lima MG, Buckner JC, Silva Jr JS, Aleixo A, Martins AB, Boubli JP, Link A, Izeni PF, da Silva MN, Röhe F, Queiroz H, Chiou KL, Di Fiore A, Alfaro ME, Lynch Alfaro JW (2017) Capuchin monkey biogeography: understanding *Sapajus* Pleistocene range expansion and the current sympatry between *Cebus* and *Sapajus*. *Journal of Biogeography* 44 (4): 810–820. <https://doi.org/10.1111/jbi.12945>
- Link A (2018) Modelo de distribución de *Cebus albifrons* ID PRI-709. Laboratorio de Biogeografía Aplicada. Instituto Alexander von Humboldt, Colombia. http://biomodelos.humboldt.org.co/species/visor?species_id=931. Accessed on: 2020-6-24.
- Lynch Alfaro JW, Silva Jr JS, Rylands AB (2012a) How different are robust and gracile capuchin monkeys? An argument for the use of *Sapajus* and *Cebus*. *American Journal of Primatology* 74 (4): 273–286. <https://doi.org/10.1002/ajp.22007>
- Lynch Alfaro JW, Boubli JP, Olson LE, Di Fiore A, Wilson B, Gutierrez-Espeleta GA, Chiou, KL, Schulte M, Neitzel S, Ross V, Schwochow D, Farias I, Janson C, Alfaro ME (2012b) Explosive Pleistocene range expansion leads to widespread Amazonian sympatry between robust and gracile capuchin monkeys. *Journal of Biogeography* 39 (2): 272–288. <https://doi.org/10.1111/j.1365-2699.2011.02609.x>
- Madden T (2013) The BLAST sequence analysis tool. The NCBI handbook, 2nd edition. National Center for Biotechnology Information (US). https://www.ncbi.nlm.nih.gov/books/NBK143764/pdf/Bookshelf_NBK143764.pdf. Accessed on: 2020-3-10
- Maldonado AM, Peck MR (2014) Research and in situ conservation of owl monkeys enhances environmental law enforcement at the Colombian-Peruvian border. *American Journal of Primatology* 76 (7): 658–669. <https://doi.org/10.1002/ajp.22260>
- Martins-Junior AMG, Carneiro J, Sampaio I, Ferrari SF, Schneider

- H (2018) Phylogenetic relationships among Capuchin (Cebidae, Platyrrhini) lineages: an old event of sympatry explains the current distribution of *Cebus* and *Sapajus*. *Genetics and Molecular Biology* 41 (3): 699–712. <https://doi.org/10.1590/1678-4685-gmb-2017-0012>
- Menezes AN, Bonvicino CR, Seuánez HN (2010) Identification, classification and evolution of owl monkeys (*Aotus*, Illiger 1811). *BMC Evolutionary Biology* 10 (1): 248. <https://doi.org/10.1186/1471-2148-10-248>
- Morales-Jiménez AL, de la Torre S (2008) *Aotus lemurinus*. The IUCN Red List of Threatened Species 2008: e.T1808A7651803. <https://doi.org/10.2305/IUCN.UK.2008.RLTS.T1808A7651803.en> Accessed on: 2020-4-30.
- Ramírez-Chaves HE, Noguera-Urbano EA (2010) Lista preliminar de los mamíferos (Mammalia: Theria) del departamento de Nariño, Colombia. *Biota Colombiana* 11 (1–2): 117–140.
- Ramírez-Chaves HE, Ayerbe-Quñones F, Mejía-Egas O (2010) Mamíferos de la cuenca Alta del río Patía en el departamento del Cauca, Colombia. *Boletín Científico, Centro de Museos, Museo de Historia Natural* 14 (1): 92–113.
- Ribeiro IP, Menezes AN, Moreira MA, Bonvicino CR, Seuánez HN, Soares MA (2005) Evolution of Cyclophilin A and TRIMCyp retrotransposition in New World Primates. *Journal of Virology* 79 (23): 14998–15003. <https://doi.org/10.1128/jvi.79.23.14998-15003.2005>
- Ruiz-García M, Castillo MI, Vásquez C, Rodríguez K, Pinedo M, Shostell J, Leguizamon N (2010) Molecular phylogenetics and phylogeography of the white-fronted capuchin (*Cebus albifrons*; Cebidae, Primates) by means of mtCOII gene sequences. *Molecular Phylogenetics and Evolution* 57 (3): 1049–1061. <http://doi.org/10.1016/j.ympev.2010.09.002>
- Ruiz-García M, Castillo MI, Lichilin-Ortiz N, Pinedo-Castro M (2012) Molecular relationships and classification of several tufted capuchin lineages (*Cebus apella*, *Cebus xanthosternos* and *Cebus nigratus*, Cebidae), by means of mitochondrial cytochrome oxidase II gene sequences. *Folia Primatologica* 83 (2): 100–125. <https://doi.org/10.1159/000342832>
- Ruiz-García M, Sánchez-Castillo S, Castillo MI, Luengas K, Ortega JM, Moreno P, Albuja L, Pinto CM, Shostell JM (2018) How Many species, taxa, or lineages of *Cebus albifrons* (Platyrrhini, Primates) inhabit Ecuador? Insights from Mitogenomics. *International Journal of Primatology* 39 (6): 1068–1104. <https://doi.org/10.1007/s10764-018-0062-6>
- Silva Jr JS (2001) Especiação nos macacos-pregos e caiararas, gênero *Cebus* Erxleben, 1777 (Primates, Cebidae). PhD thesis, Universidade Federal do Rio de Janeiro, Rio de Janeiro, 377 pp.
- Thompson JD, Higgins DG, Gibson TJ (1994) CLUSTALW: improving the sensitivity of progressive multiple sequence through weighing, position-specific gap penalties and weight matrix choice. *Nucleic Acids Research* 22 (22): 4673–4680. <https://doi.org/10.1093/nar/22.22.4673>
- Tirira D (2007) Mamíferos del Ecuador. Guía de Campo. Ediciones Murciélago Blanco. Publicación especial sobre los mamíferos del Ecuador 6, Quito, 576 pp.
- Urbani B, Lynch Alfaro J, de Azevedo R (2018) *Aotus trivirgatus*. The IUCN Red List of Threatened Species 2018: e.T41543A17923788. <https://doi.org/10.2305/IUCN.UK.2018-2.RLTS.T41543A17923788.en> Accessed on: 2020-6-7.

Appendix

Specimens Analyzed. *Aotus lemurinus*: COLOMBIA: MHN-UCa 1503 male: Caldas, Manizales, Barrio Nogales, 2029 m, skin, skull and skeleton; MHN-UCa 1504 male: Caldas, Manizales, Vereda El Chuzo, skin, skull and skeleton; MHN-UCa 3288 female: Caldas, Manizales, Barrio La Francia, 1,800 m a.s.l., skin, skull and skeleton; MHNUC 073 male: Cauca, Moscopán, skin; MUD-764 female: Nariño, municipality of Puerres, corregimiento Monopamba, El Verde, 1,931 m a.s.l., skin, skull and skeleton; MHNUC 072 male: Quindío, Salento, skin; MHN-UCa 687 male: Quindío, Córdoba, vereda Río Verde, 1,200 m a.s.l., skull and skeleton; MHN-UCa 901 female: Quindío, Filandia, Vereda Cruces, 1,861 m a.s.l., skull. ECUADOR: QCAZ 8984: Cosanga, San Isidro, skin and skull; MEPN 7918 female: Ramos, Urco, skin and skull.

Aotus vociferans: ECUADOR: MEPN 7911 female: Pastaza, Montalvo, 300 m a.s.l., skin and skull; MEPN 7888 female: Napo, Tena, river Arajuno, 400 m a.s.l., skin; MEPN 7914 female: Napo, Tena, river Napo, Boca

del río Suno, 300 m a.s.l., skin; MEPN 7915 male: Napo, Tena, river Napo, Boca del río Suno, 300 m a.s.l., skin; QCAZ 1560 male: Napo, P. N. Yasuni, Indillana, 800 m a.s.l., skin and skull; MEPN 7916 male: Pastaza, Pastaza, Pavacachi, Curaray river, 200 m a.s.l., skin; MEPN 7917 female: Pastaza, Pastaza, Pavacachi, Curanay river, 200 m a.s.l., skin and skull; MEPN 7922 male: Pastaza, Pastaza, Montalvo, 300 m a.s.l., skin and skull; MEPN 7923 male: Orellana, Loreto, Loreto (Alto Napo), skin; MEPN 10753 male: Sucumbios, Cuyabero river, skin and skull; QCAZ 161: Sucumbios, Los Monos canyon, skull and head skin; MEPN 7889: skin (no data).

Sapajus apella: COLOMBIA: MUD-762: Nariño, municipality of Puerres, corregimiento Monopamba, El Verde, 1,931 m a.s.l., skull; IAvH 6073: upper basin of the Rumiayaco - Ranchería rivers, skull.

Cebus albifrons: COLOMBIA: MUD-763: Nariño, municipality of Puerres, village of Monopamba, El Verde, 1,931 m a.s.l., skull; IAvH 6070: upper basin of Rumiayaco - Ranchería rivers, skull.